

“Brick Wall” Approximation of Carrier Synchronization Losses for High Performance Channel Codes

by

Shervin Shambayati

Strong channel codes have always been of interest for use in deep space telecommunications due to their high performance. However, there has always been a concern about the degradation of their performance due to imperfect carrier synchronization. In this paper, a “Brick Wall” approximation of carrier synchronization losses (Radio Losses) is presented. In this approximation, the frame error rate performance of a code is approximated by a step function such that

$$f_{FER}\left(\frac{E_b}{N_0}\right) = \begin{cases} 1 & \frac{E_b}{N_0} < \left(\frac{E_b}{N_0}\right)_{thresh} \\ 0 & \frac{E_b}{N_0} > \left(\frac{E_b}{N_0}\right)_{thresh} \end{cases} \quad (1)$$

This approximation of the frame error rate function is then used in standard equations for radio losses. By using this function, the radio losses obtained are independent of $\left(\frac{E_b}{N_0}\right)_{thresh}$ and are thus applicable to any high performance channel code.

This approximation is used to calculate radio losses for when carrier synchronization is performed by a phase locked loop. For different frame error rates this approximation is calculated and then compared to the actual radio losses for Turbo Codes and concatenated codes for different phase locked loop signal to noise ratios. The results indicate that this approximation is highly accurate (within 0.5dB of the actual value) for phase locked loop signal to noise ratios higher than 11dB. In addition, this approximation is shown to be more accurate for stronger codes. Also, this approximation can be used as a tool to simplify link budget calculations as newer and stronger channel codes become available by providing an accurate approximation of their radio losses without needing to calculate them for each new code. Finally, this approximation indicates that the performance advantage that one strong channel code has over another with perfect carrier tracking translates to nearly the same advantage under imperfect carrier tracking conditions.